Seismic performance of a 9-storey pre-1970s reinforced concrete wall building in Wellington

Farhad Dashti, Reagan Chandramohan, and Rajesh P. Dhakal

University of Canterbury, Christchurch

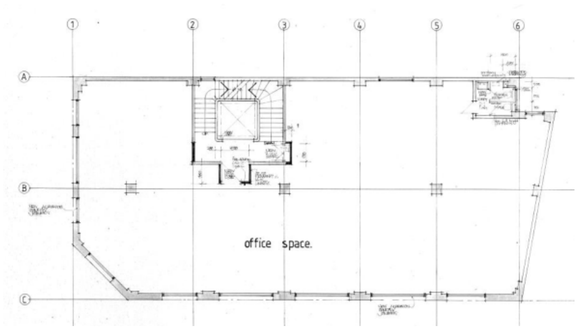
Background and motivation

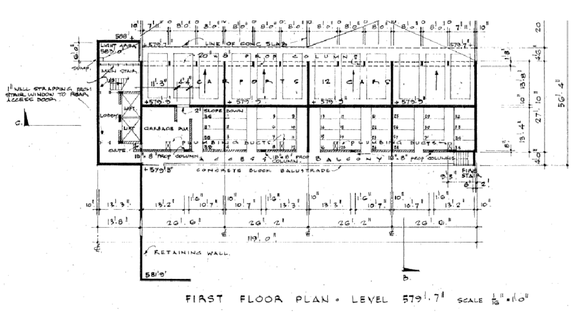
- $2/3^{rd}$ of the reinforced concrete (RC) buildings in the Christchurch CBD were demolished due to the damage they sustained in the 2010–11 Canterbury earthquakes, significantly impacting the residents' lives and the local economy
- Wellington contains more than seventy pre-1970s non-ductile RC wall buildings, ranging in height from 5 to 18 storeys, that are likely to suffer a similar fate after a moderate magnitude earthquake on the Wellington fault

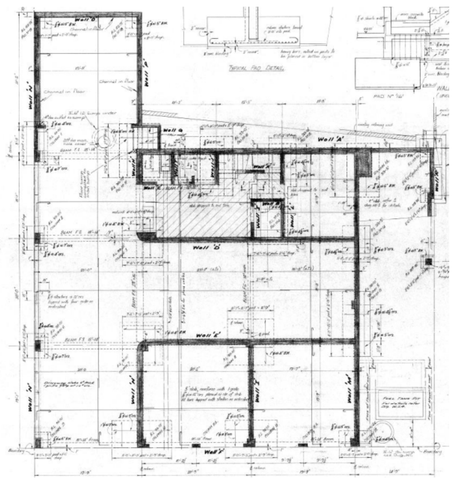
Objectives

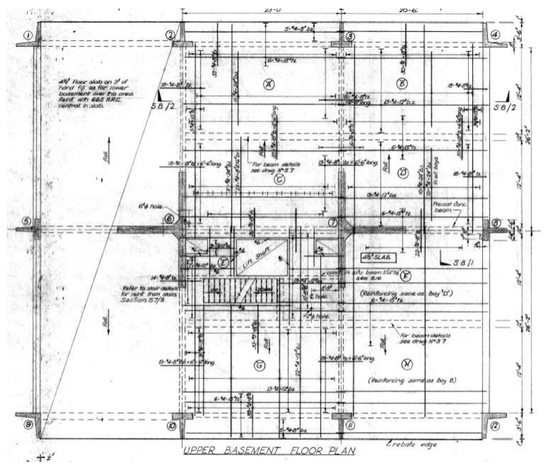
- Analyse common structural wall configurations of pre-1970s non-ductile RC buildings in Wellington
- Numerically simulate the response of selected representative buildings under hazard-consistent ground motions to evaluate their seismic performance
- Quantify the seismic risk due to pre-1970s RC wall buildings in Wellington

Structural wall configurations

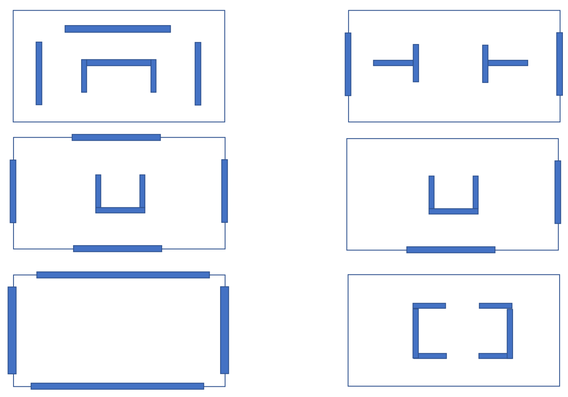






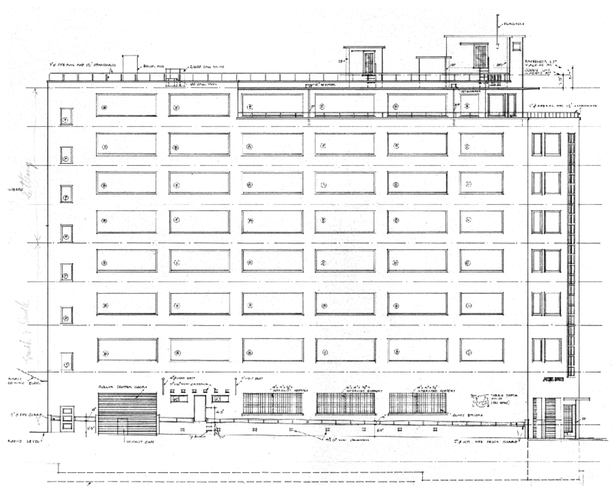


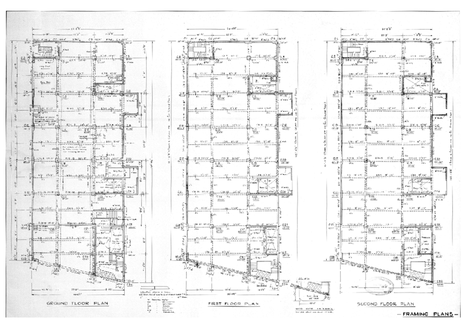
- Most buildings were observed to have variations of the following simplified structural wall configurations

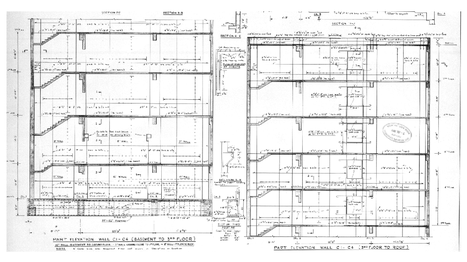


- A number of buildings were found to have additional structural deficiencies such as irregular plans, soft stories, and discontinuous walls

Selected representative building

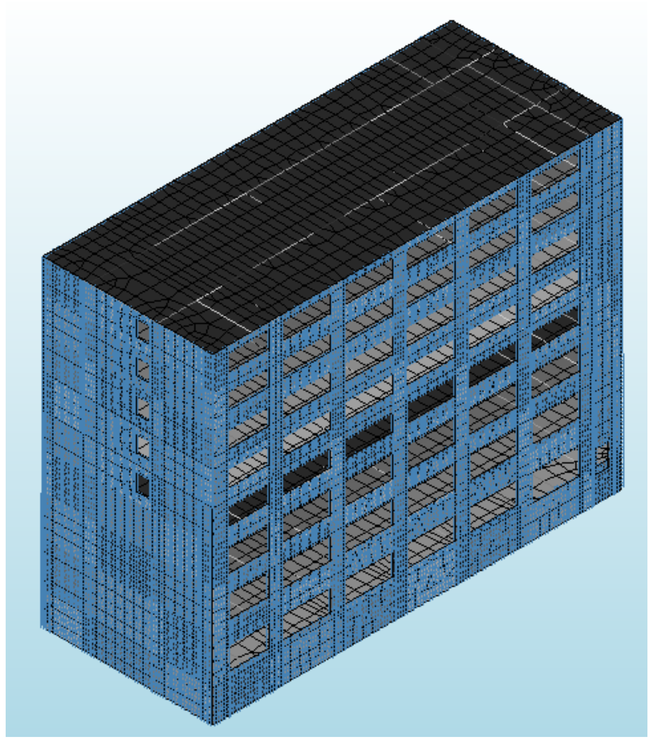


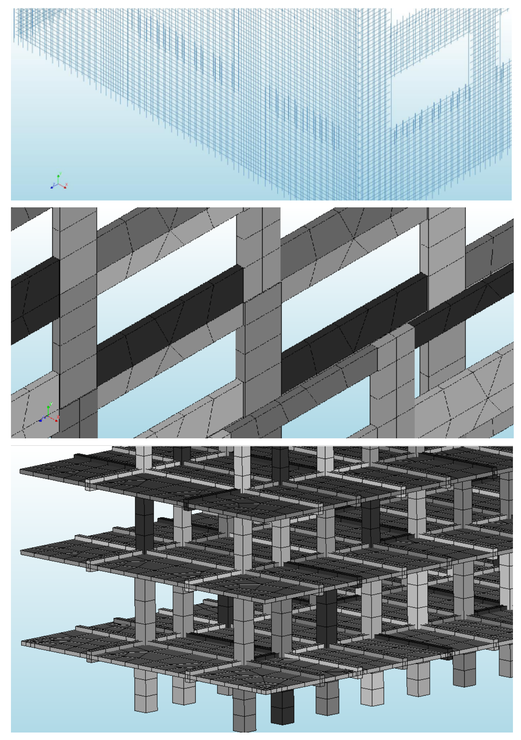




- The 9-storey office building shown above was chosen as a representative building for detailed numerical modelling and analysis

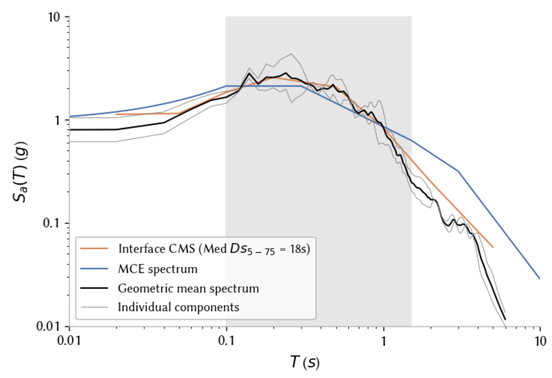
Numerical model

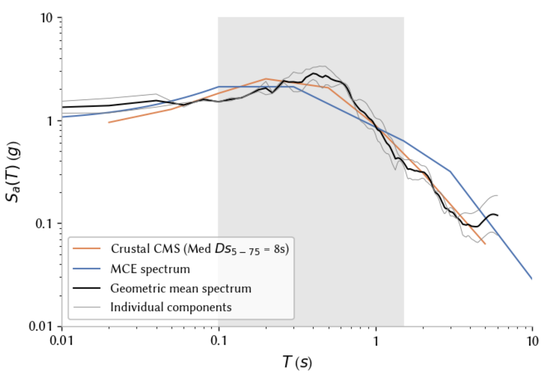




- A detailed 3d continuum model of the building was developed in DIANA
- RC walls were modelled using curved shell elements, which have been previously shown to accurately capture their nonlinear response, including shear and out-of-plane deformations, as well as the various failure modes observed in experimental tests
- Floor slabs were also modelled using curved shell elements, but with linear material properties
- Beams and columns were modelled using line elements with confined nonlinear material properties

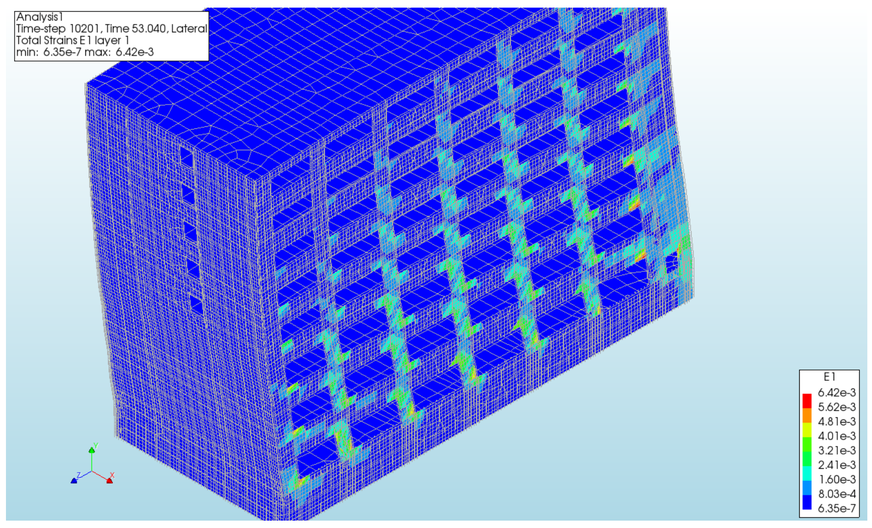
Selected ground motions

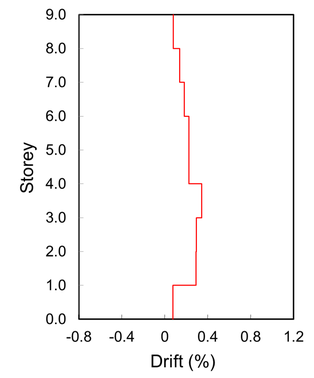


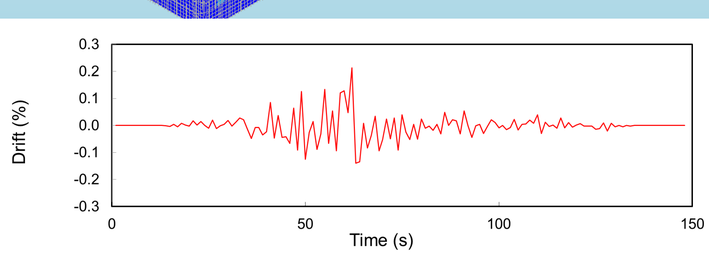


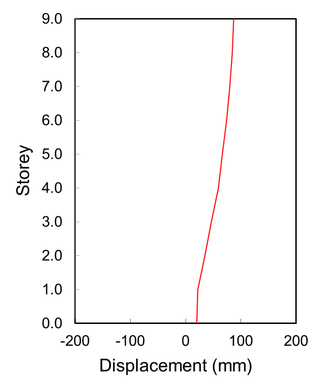
- One and two pairs of horizontal ground motions were selected to match the conditional mean spectra and conditional mean target durations corresponding to ground motions anticipated at the site in Wellington at the 2 % and 10 % in 50 year hazard levels from interface and crustal earthquakes respectively

Analysis results









- The dynamic response of the building was simulated using the selected ground motions
- The simulated drifts were observed to be relatively small due to the relatively large wall area and lateral stiffness of the building
- The model was then perturbed to introduce deficiencies such as torsional irregularities and wall discontinuities to capture these characteristics observed in other Wellington buildings, and re-analysed under the same ground motions

Future work

- The PEER performance-based earthquake engineering (PBEE) framework will be applied to quantify the seismic risk of the selected building
- Results from the perturbed model simulations will be used to study the anticipated failure modes and assess the expected seismic risk of other pre-1970s RC wall buildings in Wellington